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DETERMINATION OF IONIZATION POTENTIAL OF Gd AND Ho BY SURFACE IONIZATION METHOD

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(*Received February* 8, 1966)

Several authors (Ionov and Mittsev, 1960, 1961; Alekseev and Kaminskii, 1965) determined the first ionisation potential of a number of rare earth elements by comparing with the known I. P of some other elements and Dresser *et al* (1965) determined the I.P. of Gd, Er and Yb directly with the help of the surface ionisation process In the present work we report the values of I.P. of Gd and Ho directly determined by the surface ionisation method with a new and simpler procedure. From the Saha-Langmuir equation, we have

$$\frac{n^+}{n_a} = \frac{g_+}{g_a}\, e^{(\phi - I)/kT} \qquad \ldots \quad (1)$$

where n^+/n_a is the ratio of the number of evaporated ions to neutral atoms from a filament surface of electron workfunction ϕ and maintained at a temperature T. I is the ionization potential of the evaporating atoms and k is the Boltzmann constant. g_+ and g_a are the statistical weights of the ions and atoms respectively. As $(I-\phi)$ is greater than kT over the entire range of variation of kT in the present case, equation (1) takes the form .

$$n^+ = nG\, e^{(\phi_{av} - I)/kT} \qquad \ldots \quad (2)$$

or

$$I^+ = nAGe^{(\phi_{av} - I)/kT} \qquad \ldots \quad (3)$$

where I^+ is the positive ion current, n is the sum of n^+ and n_a, G is the ratio g_+/g_a, A is some constant, ϕ_{av} is the average work function of the polycrystalline tungesten filament surface used in this experiment

From equation (3) it is evident that if n is maintained constant, the $\log_{10} I^+$ *vs* $\frac{5040}{T}$ plot will be a straight line of negative slope, which determines $(I-\phi_{av})$, assuming G to be constant over the temperature range under consideration. Determining ϕ_{av} from the Richardson plot, I can be determined.

Experimental set up consisting of a three filament ion source with an ion extraction slit system, electrometer ion detector and method of procedure have already been reported (Dey, 1965) with the results of the measurement of the

I.P. of Li The two side filaments of the ion source are now surrounded by glass capsules with radial holes in them for facilitating the introduction of the volatile rare earth chlorides and also to allow the vapour to come out when heated.

RESULTS AND DISCUSSIONS

The ion source chamber is evacuated to a pressure of better than 10^{-5} mm of Hg with a 4″ inch oil diffusion pump and liquid oxygen used in a suitable trap. The electron current from the central filament is measured for varying temperature,

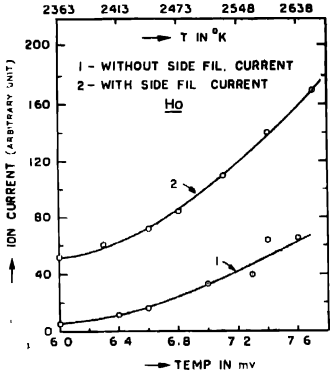

Fig. 1(*a*). Variation of ion current with temperature for Holmium.

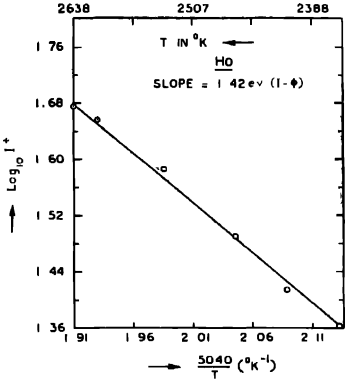

Fig. 1(*b*). Graphical plot of $\log_{10} I^{+}$ vs $5040/T$ for Holmium.

which is measured by a tungsten-molybdenum thermocouple (Morgan *et al*, 1950). From the Richardson plot the value obtained for ϕ_{av} is 4.68 ± 0.07 ev.

Chlorides of Gd and Ho are used. The variation of ion current with temperature is noted with and without molecular beam. $(I-\phi_{av})$ practically remains constant roughly over the temperature range 2200°K-2700°K, the temperature being measured with the $W-Mo$ thermocouple. Mean I.P. for Gd from a set of measurements is found to be 6.73 ± 0.09 ev. in good agreement with the value obtained by Dresser *et al* (1965).

Fig. 1(*a*) shows the variation of Ho ion current with temperature with (Curve 2) and without (Curve 1) the molecular beam and in Fig 1(b) the log I^+ *vs* $\frac{5040}{T}$ plot is shown. The mean value of I.P. from sets of four observations is 6.08 ± 0.09eV comparable with the value (6.19 ev) obtained by Alekseev *et al* (1965). No spectroscopic data for directly determined value of I.P. of Ho by surface ionisation method is available for comparison with our results.

The spectroscopic value of I.P. for Gd is 6.16 ev (Moore, 1963) which is lower than the present value. This discrepancy may possibly be explained by the fact that the Saha-Langmuir theory needs modifications in case of surface ionization of complicated atoms in beams as indicated by Dresser *et al* (1965).

Thanks are due to Prof. D. N Kundu and Prof. B. D. Nagchaudhuri for constant encouragement and to Mr. M. K. Chakravarty for technical assistance.

REFERENCES

Alekseev, N. I. and Kaminskii, D. L., 1965, *Soviet Physics. Technical Physics* **9**, 1177.

Dey, S. D., 1965, *Proc Nucl. Phys and Solid State Phys* Symposium held in Calcutta in February, Nucl. Phys 309.

Dresser, M. J. and Hudson, D. E., 1965, *Phys. Rev.* **137**, 2A, A 673

Ionov, N. I. and Mittsev, M. A. 1960, *Soviet Physics—JETP* **11**, 972.

————, 1961, *Soviet Physics—JETP*, **13**, 518.

Moore, C. E., 1963, *Applied Optics*, **2**, 665.

Morgan, F. H. and Danforth, W. E., 1950, *Jour. App. Phys.* **21**, 112.